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# THE SALTON SEA.\*

BY EDMUND MITCHELL.

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It will surprise most people to learn that, owing to a diversion of the course of the Lower Colorado River, Southern California has, within the past two years, added to its geographical features a lake that covers an area of more than four hundred square miles, is surely destined to attain to much greater dimensions, but is already, without reckoning Lake Michigan, the largest sheet of water, next to the Great Salt Lake of Utah, wholly within the boundaries of the United States of America. Rarely, indeed, is such a vast change on the face of Nature witnessed in the actual process of its making, and more wide-spread attention would ere this have been attracted to the Salton Sea—as the

\* Since this article was written, the chances of regaining control of the Colorado River have been rendered still more remote by the effects of the summer flood. Although the engineers at the intake works had confidently predicted that they would hold the river before this flood, they failed to do so. In mid-June, the Colorado at Calexico was ten miles wide, and this vast body of water was pouring down into the Salton Sea by the New River channel. The lake rose from June 3rd to June 19th, as shown by the Government gauge at Salton, from 43.78 feet to 52.02, or more than 8 feet in 15 days. At this writing (July 1st), the lake is only two miles away from the prosperous agricultural settlement of Mecca, which will soon inevitably be obliterated from the map of California. But the most serious result of the great summer flood has been the "cutting back" of the river bed from the lake toward the intake. A receding waterfall has been formed, to which the fine sandy loam can offer no resistance, and a cañon has been cut, a thousand feet wide and thirty feet deep, right through the Imperial country. On June 30th, this turbulent ledge of tumbling waters swept the small Mexican town of Mexicali, just across the border from Calexico, out of existence. The cutting back toward the intake is continuing at the rate of nearly a mile a day. If the old river bed below Yuma is reached and subjected to this process, all attempts to change the river from its new and deep-dug channel may be abandoned. Even the Government dam at Laguna is now endangered, for the cutting back, unless checked, will go right up the river to the Grand Cañon; and the Laguna dam, as explained in the article, rests simply on a bed of silt, being constructed to resist flood waters above, but not the scooping out of silt from below.

—E. M.

new lake is named from the Salton Sink, the depression it is filling—but for the fact that until recently only a desert area, almost entirely unoccupied by man, has been affected.

Now, however, owing to the continued extension of the inundation, important interests are becoming involved. The main line of the Southern Pacific Railway traverses this southwest corner of the Great Colorado Desert, and, by a series of submersions, its road-bed is being gradually driven off the plain toward the foothills of the adjacent mountains. Agricultural areas, too, that within recent years have been reclaimed from the wilderness by great irrigation works, as well as by stalwart individual effort, are seriously menaced.

Then, to cap the climax, international complications are in sight. For the Colorado River is not exclusively in possession of the United States, but has its lower course in Mexico; and, by the diversion of the stream from its original bed, not only are waters formerly available for irrigation in Mexico now being impounded in United States territory, but navigation rights, which play an important part in the treaty subsisting between the two countries, have vanished with the vanishing of the navigable stream and the failure of engineering efforts to restore the former order of things. Hence the recent appointment by the Mexican Government of a special commission of investigation, headed by Brigadier-General Angel Garcia Peña and including in its ranks other distinguished engineers.

For all these reasons the Salton Sea ceases to be merely a matter of local interest; it is obviously a happening of national and historical importance.

To the scientific world also the event is of real interest. We are witnessing a reversion to an order of things that had a prior existence in some remote period of the earth's history. For, as the fresh-water shells deposited in vast quantities all over the depression prove, the Salton Sink was formerly a great lake, banked up by the accumulated silt of the delta forming a natural dam. These very conditions are recurring at the present time, and the change is not so slow, like most of Nature's changes which are going on around us, as to be almost imperceptible, nor so sudden and violent, like the changes wrought by an earthquake or a volcanic eruption, that the causes at work are obliterated by the very catastrophe. Therefore, the student of

geological science can here study at his leisure the forces of Nature in visibly effective operation, transforming the face of the earth just as theory tells us it has often before been transformed.

The transformation, indeed, is a striking and dramatic one. In the fall of 1903, I spent a holiday of several weeks in traversing the Salton Sink. By aid of a mule team, we had to pack water over a desolate waste, so arid that only cacti and the meanest kind of scrub could struggle for an existence on its desiccated and alkali-impregnated soil, so bare and barren that even the jack-rabbit and the horned toad counted it out of habitable bounds. Right in the centre of the depression, where the last trace of vegetation had disappeared in a shimmering sheet of efflorescent salts, we watched a tiny train puffing along with its load of crystals toward the works where, amidst great white pyramids of the accumulated salt, wheels were whirring and rollers grinding.

When, on that occasion, I gazed for the last time upon the Salton Sink in its dry-land state of being, a superb mirage had transfigured the scene into a phantom lake, from out of which, befogged by the heat haze, loomed the salt-works amidst its mounds of salt, for all the world like a storm-battered hull of an ocean derelict surrounded by icebergs. Little did I then dream that on my next visit—this last December—I should behold in actuality a vast inland sea, in which had been engulfed the accumulations of salt, the mill and all its paraphernalia. In place of the delusive mirage was an expanse of real water, blue as the cloudless skies whose color it reflected, along one edge lashed into white-capped billows by a slant of strong desert wind. And this new lake had already become the resort of tens of thousands of geese, ducks, cranes and other water fowl, attracted in their southward migratory flight by a glimpse from on high of these new and enticing winter quarters.

To make clear the change that has taken place and is still continuing, a few words of topographical explanation will be necessary. Yuma, close to the State border-line between Arizona and California, is 140 feet above sea-level. Past this town the Colorado River flows south toward the Gulf of California, a course of about seventy miles, with the gradual descent, therefore, of but two feet to the mile. But, from Yuma westward, the dip of the land is both deeper and more abrupt, so that at

Salton, ninety-three miles distant, the depression is no less than 263 feet below sea-level, the gradient being thus over four feet to the mile. From this lowest point, as we still move west, the country rises, and now at a sharper angle, for Indio, only twenty-five miles from Salton, is but twenty feet below sea-level, while Palm Springs, nineteen miles further on, has an elevation above sea-level of 584 feet. It is just beyond Palm Springs that the Southern Pacific Railroad emerges, through the grim San Geronio Pass, from the desert region into the fertile agricultural belt of Southern California.

This great saucerlike hollow, 137 miles across from Yuma to Palm Springs, with some sixty-five miles of the distance actually below the level of the sea, is bounded on the north by a broken-up series of ranges known collectively as the San Bernardino Mountains. On the south, running eastward from the San Geronio Pass, is the sweeping curve of the massive San Jacinto range. But, when Salton is reached, there is only a protruding spur of the range in evidence, and soon this also disappears, leaving toward the south the broad open plain now known as the Imperial Valley, where for some years past a great irrigation project has been in progress. Imperial Valley rises at a sharp pitch out of the Salton Sink, for Calexico, on the Mexican border, just forty miles south of Salton, is at sea-level. This is the limit of the United States lands, but the physical features of the country continue to be identical across the border-line, there being a steady uplift toward the Cocopah Mountains on the southern horizon.

Now will be understood the precarious position that has been occupied up to recent times by the Lower Colorado River. In point of fact, it has been flowing south along the rim of a deep hollow that lies to the west of its course. For a distance of about twelve miles below Yuma, a barrier of sand-hills prevents the current from taking the direction of the Salton Sink, its natural destination, as being the lowest point of depression. But, after passing this sand-hill ridge, the river, in the bed it occupied until recently, continued on its way through Mexico, a sluggish stream, depositing its heavy burden of silt scoured from a thousand miles of cañons. To the right lay old and disused channels, into which some water spilled at flood time. But the river had dug its main bed from north to south through its own silt accumulations,

and with only occasional changes, due to the caving-in of banks or the forming of new sand-bars, was content to keep to this course until the hand of man came to interfere with the delicately balanced condition of things.

Five years ago, the California Development Company set itself to supply irrigation water to the Imperial Valley, rich lands formed of Colorado silt deposited centuries ago, and requiring, in a climate of perpetual sunshine, only moisture to make them highly productive. The Colorado River was the natural source of water-supply. But, owing to the sand-hill barrier above referred to, a canal in United States territory directly west from the river bed was impossible. The channel must follow a sweeping curve through Mexican territory, until, bending back to the north, it could enter the Imperial country on its southern boundary. The necessary right of way through these Mexican lands was acquired from the owners, and the canal was dug, an old disused channel of the Colorado, known as the Alamo River, being largely taken advantage of in the engineering operations.

The intake, of course, was on United States soil, as the diverted water was required primarily for the irrigation of United States lands. The spot selected was eight miles down the Colorado River from Yuma—that is to say, almost at the limit of United States territory on the California side of the stream. As the spit of sand-hills above referred to had to be rounded, the canal and the river, for the first few miles across the Mexican border, followed nearly parallel courses. No head-gates were put into the canal; the river water was simply allowed to flow in, just as into an open ditch. This was economy as regards construction expenses certainly, but very costly economy in the long run, as the sequel proved.

The first few miles of the ungated canal has but a very slight fall, and, there being no settling basin provided above the intake, it followed in the natural order of things that the channel became clogged up with silt. In the summer of 1904, it came to be realized by those responsible that the ditch was no longer carrying enough water to supply the wants of the Imperial Valley lands already under cultivation. To dredge out the canal for six or seven miles would have been an operation requiring time, and already the danger of ruined crops had grown to be an urgent one. So the Company decided upon taking a quick

(and once again a cheap) method of supplying its necessities. Four miles below the original intake, and therefore in Mexican territory, it scooped out a cross-ditch connecting the river directly at this second point with the canal. Once again no head-gates were put in—no mechanical devices of any kind for controlling the flow of the water were provided.

It was this emergency work, originally a shallow and narrow trench, that eventually proved to be the first tiny breach in Nature's own system of protecting levees. For through this aperture, scoured deep and wide by a succession of floods, the entire waters of the Colorado River, instead of passing gently south to the Gulf of California, are now rushing down impetuously and uncontrollably into the Salton Sink. In other words, the Imperial Canal is now the Colorado River, restored to its ancient bed, the Alamo watercourse.

The winter of 1904-05, after a long series of years of comparative drought, proved to be a season of abnormal rainfall all over the southwest. Among the mountain regions of Arizona there were rain-storms of unprecedented violence and frequency. In consequence, the Gila River, the great Arizona tributary of the Colorado, joining it at Yuma, also its subtributary the Salt River, flowing past Phoenix and thence into the Gila, rose in a succession of heavy winter floods. It was these floods that began the process of scouring out the narrow emergency ditch. The regular summer floods of 1905, due to the melting snows in the High Sierras among which the upper Colorado has its course, continued the work, and, when the danger came to be realized, the breach was practically beyond repair.

The steady rise of the waters in the Salton Sea, disregarded until the railway began to be driven from its road-bed, drew attention to the full seriousness of what was happening. The Southern Pacific Railway Company was virtually compelled to come to the financial assistance of the California Development Company, and all through the fall months of 1905 desperate and continuous efforts were put forth to turn back the Colorado into its old channel. Attempts were made to dam the emergency cross-ditch by double rows of piles, with brushwood mats weighted by sandbags dropped between them. But, after the relentless river had two or three times breached this feeble barrier during its construction, finally a mighty flood on November 30th, the

second highest ever recorded on the Colorado River, and once again caused by abnormal rains in Arizona, turned the whole plan into ridicule. The effect was not so much to break down the dam, as to cut everything away around it; for there are no rocks to serve as foundations and abutments in this land of silt, which, in renewed contact with water, at once becomes quicksand, so that a strong current speedily sweeps round both ends of any obstruction.

A few days after this flood, I descended the river from Yuma in a steamboat, in company with the Mexican commissioners. We found that the river had now indeed completed its task of making for itself a new and permanent bed. The old channel was practically dry and choked with silt. The full stream was rushing in a sweeping curve through the cross-ditch into the Imperial Canal. The cutting work was still going on, for, as we watched from the deck of the steamer, great slices of soil with their growth of brush—young cottonwood and willow trees, together with tall arrow-weed—were being engulfed in the swirling stream. For fifteen miles our vessel sailed down a broad and swift-flowing river that had once been the placid Imperial Canal. We were in the old Alamo channel, once again, after many centuries perhaps, a navigable stream. We were being borne, not seaward to the Gulf of California, but back into United States territory—down into the Salton Sea. The mighty river had ceased to flow to the ocean.

Such is the present position of things. Since December last, all the waters of the Colorado have been pouring into the Salton Sea, by the Alamo channel and by another old channel known as the New River, which was formerly merely a spillway at the time of the big summer flow. During the past winter, once again there has been a recurrence of abnormal rain-storm floods, which have served to scour deeper the new beds of the river, while the sluggish backwash, depositing its silt, has still more effectually sealed the old bed. The Salton Sea has been rising at the rate of about six vertical inches per week, and the area of the lake is thus steadily and inexorably extending. At Salton, the water is nearly thirty feet deep, as measured by the telegraph poles marking the original line of the Southern Pacific Railway, the tips of which, far out to sea, now just show above the surface. Therefore, the lake-level is still some 230 feet below sea-



level, and it has been calculated that, should the waters of the river continue to flow into the basin in their present volume, after making the proper allowance for evaporation, it will take from thirty to forty years to fill the entire saucerlike depression up to sea-level. Should this ever happen, there would be a lake nearly 2,000 square miles in area, the overflow waters of which would eventually reach the Gulf by some new channel cut through the barriers of silt at their weakest point of resistance.

How then is the full filling up of the Salton Sea to be prevented? The question is one of national importance, for, although up to the present merely a desert region has been affected, in the end hundreds of thousands of acres of rich agricultural lands would be submerged, and the country so be deprived of one of its most magnificent domains, even now to a considerable extent under high cultivation, but capable, with irrigation, of being converted in its entirety into a closely settled region of teeming productivity that would compare with the delta of the Nile.

There are certain engineering operations at present going on at the old intake of the Imperial Canal, with a view to regaining control of the river, but these may be disregarded as belated, inadequate, and no more likely to succeed than the previous futile endeavors at this point. The real hope of safety against the indefinite encroachments of the Salton Sea lies higher up the river—at Laguna, twelve miles above Yuma, where a great dam is under construction by the United States Government. In the course of my investigations, I visited this spot, and found the operations well under way. Two years will see them completed.

At Laguna, mountain walls of granite come close together on the two sides of the river—the California side and the Arizona side. These afford solid abutments for the building and anchoring of the great dam, and the very first thought that strikes the observer is that here indeed is the ideal spot where the mighty Colorado River may be mastered, manacled and held in perpetual bondage. The hand of Nature has been stretched forth, and needs only the responsive hand-clasp of the engineer to establish for all time supremacy over the riot-running and havoc-working stream.

The dam will stretch from rock abutment to rock abutment,

a distance of 4,800 feet. It will be formed by three massive concrete walls, parallel with each other, the spaces between filled with lumps of rock blasted from the mountains, the whole barrier 244 feet broad on top. This virtually solid mass of rock and concrete, the very interstices in which will in course of time be filled up with silt, will weigh 600,000 tons, and although it will rest simply on the river bed, there being no bed-rock attainable, with sheet piling driven down to form a curtain upstream and so prevent seepage, it will form an impregnable barrier at low water, while flood waters will spill over the top. This is precisely the type of dam that, from time immemorial, has been effective in dealing with such rivers as the Ganges and the Nile, which closely resemble the Colorado.

While the Laguna dam has been primarily designed to reclaim and irrigate some 100,000 acres of rich river-bottom lands, four-fifths of them lying below Yuma on the Arizona side, it affords the basis of a big and comprehensive engineering scheme, which will eventually establish an effective control over the Lower Colorado, meet every irrigation requirement, and apply the waters to the best advantage and over the widest area possible. For the protection of the bottom-lands immediately to be irrigated, great levees are being built, and within these will be the canalization systems. At times of lowest flow, practically the whole volume of the river can be diverted, at least temporarily, into the irrigation channels, so that it will be possible to make effective repairs at the point where the river has burst its way into the Imperial Canal. Levees here, constructed under such conditions, will be substantial enough to turn the river back into its old bed, which the first freshet will scour out anew. In the end the Imperial intake must be moved up to Laguna, so that in the future there shall be no more liberties taken with the dangerous and treacherous river—no more constructing of canals without head-gates or digging of emergency ditches without thought of the final consequences involved. Then will the diversion of the waters rest, as it should do, under one single responsible control. The works at Laguna are being carried out on a plan that holds in view this ultimate object of irrigating from this point the whole Imperial Valley country, just so soon as the private interests involved can be bought out on terms equitable to all concerned, the national exchequer included.

Complementary to the Laguna dam, and an essential factor in the whole scheme of controlling the waters, is the great storage reservoir now being built on the Salt River, a tributary of the Gila River. It is these two subsidiary streams that have been almost solely responsible for the winter floods of the Lower Colorado, which of late years have so seriously complicated the problem, and of course are liable to do so again.

With the Laguna and Salt River works completed, insuring both conservation and regulation of the waters that have hitherto run mostly to waste and very frequently to riot, then at last will the Lower Colorado River fairly be held in subjection. Thenceforward, its waters will be available for the irrigation of great stretches of country now given over to jack-rabbits and sagebrush. And it is precisely in this full utilization of the river flow for agricultural purposes that will eventually be found effective and adequate safeguards against the indefinite expansion of the Salton Sea. But the great inland lake will be with us for at least a generation, and indeed it may be found for the permanent good of the region that it should be permanently maintained as the overflow reservoir of the Colorado.

This brings us face to face with the international issues involved. By treaty between Mexico and the United States, the Colorado River is recognized as a navigable stream, a highway of commerce to be preserved as such for the joint benefit of both countries. For Mexico, however, navigation on the Lower Colorado has never been of any real value; amidst the wide-spread, fan-shaped delta region, there is no settlement, no commerce, no shipping. Then, as regards the United States, the coming of the transcontinental railway to Yuma has completely discounted the value of navigation rights from the Gulf through Mexican territory. In the old days, when Yuma was a frontier post and distributing centre, because of its position on a navigable stream, stores used to be brought there by way of the Gulf. But for years past never a cargo boat has come up the Colorado. At rare intervals, there have been excursions down the river for sight-seeing purposes; also an occasional traveller, counting himself almost an explorer, has hired Indians to row him to the Gulf. That is about the sum total of the benefits secured to the United States by the treaty calling for the maintenance of navigation privileges on the Mexican section of the Colorado.

Therefore, although the international agreement, concluded at a time when irrigation was never so much as thought of, sets store only on conserving the rights of navigation, for neither country now has navigation any real value. It is irrigation that has come to be the question of dominating importance on both sides of the border-line, and, if the waters of the Colorado are to be fully or even largely utilized for agricultural purposes, useless navigation rights—in point of fact, non-existent now because of the diversion of the stream to the Salton Sea—must be definitely abandoned.

Careful calculations made by the United States Government engineers show that, on the Colorado River below the Grand Cañon, there are lands irrigable, but not yet irrigated, extending to 1,499,000 acres. These are distributed as follows: In Arizona, 394,000 acres; in California, 417,000 acres, including 275,000 acres in the Imperial Valley reckoned as good agricultural lands; and in Mexico, outside United States territory, 688,000 acres. Thus the irrigable lands are pretty equally divided between the two countries. But, even with complete conservation and regulation, the waters will not suffice for the irrigation of the whole of this area. At most 1,000,000 acres, according to the Government engineers, can be served in years of normal flow.

It therefore follows that some equitable scheme for a division of the waters between the two countries must be devised. It might be argued that, in so much as the precipitation of the rainfall that feeds the Colorado River and its tributaries is almost entirely in the United States, the stream, so long as it runs within United States territory, can be dealt with by the American people exactly as they choose—in other words, that the whole of the waters may be impounded for irrigation purposes on this side of the frontier line. But such a contention cannot stand close scrutiny. Apart from the selfishness of the suggested procedure, on broad general principles of equity the upper riparian owner cannot rob the lower riparian owner of water which the latter has been accustomed to enjoy. Then, again, while there are no clauses in the international treaty bearing upon irrigation, the clauses which deal with navigation cannot be ignored and set aside by one party alone. For, if the waters of the Lower Colorado come to be withdrawn on the United States side of the border for use in irrigation, so as permanently

to destroy navigation on the Mexican side, clearly Mexico is in a position to demand the restoration of the navigable stream that is secured to her by treaty. Mexico may justly say: "Claim the water, if you will, as yours in its origin, but its use for navigation purposes is guaranteed to us under the specific conditions of our old international agreement. If you deprive us of navigation, we are entitled to irrigation by way of compensation for the rights we are called upon to surrender."

I am aware that the exact interpretation of the treaty of Guadalupe Hidalgo, 1848, subsequently modified by the Gadsden treaty of 1853, which shifted the border-line twenty miles further south on the Arizona side of the river, affords scope for some fine hair-splitting legal argument. Reading the mere words without reference to the spirit of the agreement, we might contend that the rights of navigation from the Gulf up the Colorado River were guaranteed to the United States by Mexico, but not to Mexico by the United States. To this comes the obvious rejoinder that the reciprocal guarantee to Mexico was unnecessary, simply because the stretch of river to be navigated lay within her territory. But apart altogether from such verbal niceties of interpretation, the clear intention of the agreement was to prevent any obstruction to navigation on the Lower Colorado up to the international boundary line, from whatever quarter proceeding. The treaty in the beginning was undoubtedly in favor of the United States, for it secured for this country access from the open sea to its inland territory and through its neighbor's territory. Now, it may seem to work in favor of Mexico, for it retains for her the preservation of the navigable stream when navigation has become of quite secondary importance as compared with irrigation. But the mere shifting of the position of relative advantage does not destroy the mutuality of the obligations imposed by the agreement.

When the Imperial Valley irrigation scheme was first started, involving engineering works on both the American and the Mexican side of the international line, the need of a conference between the two Governments and a readjustment of the existing treaty bearing on the Lower Colorado River loomed up on the horizon. What was desirable then, however, is urgent now, because of the grave complications resulting from these same operations—navigation to the Gulf destroyed; the Salton Sea fill-

ing up with waters which, whatever their first origin, come directly across the line from Mexican territory; damage caused by flooding to a certain number of settlers in the Imperial Valley; a great railway company driven to seek a new road-bed for its tracks; and all this with no guarantee that there is to be any break in the chain of disastrous events, unless a comprehensive scheme for the control of the waters, such as that offered by the Laguna proposition, when carried out in its entirety, can be decided upon under an agreement that shall be just and equitable to both Governments. To reach such an agreement, it is obvious that there must be giving and taking on both sides.

EDMUND MITCHELL.